Decline in Renal Function after Partial Nephrectomy: Etiology and Prevention

Maria C. Mir, Cesar Ercole, Toshio Takagi, Zhiling Zhang, Lily Velet, Erick M. Remer, Sevag Demirjian and Steven C. Campbell*

From the Glickman Urological Kidney Institute (MCM, CE, TT, ZZ, LV, EMR, SD, SCC) and Imaging Institute (EMR), Cleveland Clinic, Cleveland, Ohio; Department of Urology, University of Miami, Miami, Florida (MCM); Department of Urology, Tokyo Women's Medical University, Tokyo, Japan (TT); and Department of Urology, Sun Yat-sen University Cancer Center, Guangzhou, Guangdong, China (ZZ)

Purpose: Partial nephrectomy is the reference standard for the management of small renal tumors and is commonly used for localized kidney cancer. A primary goal of partial nephrectomy is to preserve as much renal function as possible. New baseline glomerular filtration rate after partial nephrectomy can have prognostic significance with respect to long-term outcomes. Recent studies provide an increased understanding of the factors that determine functional outcomes after partial nephrectomy as well as preventive measures to minimize functional decline. We review these advances, highlight ongoing controversies and stimulate further research.

Materials and Methods: A comprehensive literature review consistent with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria was performed from January 2006 to April 2014 using PubMed®, Cochrane and Ovid Medline. Key words included partial nephrectomy, renal function, warm ischemia, hypothermia, nephron mass, parenchymal volume, surgical approaches to partial nephrectomy, preoperative and intraoperative imaging, enucleation, hemostatic agents and energy based resection. Relevant reviews were also examined as well as their cited references. An additional Google Scholar search was conducted to broaden the scope of the review. Only English language articles were included in the analysis. The primary outcomes of interest were the new baseline level of function after early postoperative recovery, percent decline in function, potential etiologies and preventive measures.

Results: Decline in function after partial nephrectomy averages approximately 20% in the operated kidney, and can be due to incomplete recovery from the ischemic insult or loss of nephron mass related to parenchymal excision or collateral damage during reconstruction. Compensatory hypertrophy in the contralateral kidney after partial nephrectomy in adults is marginal and decline in global renal function for patients with 2 kidneys averages about 10%, although there is some variance based on tumor size and location. Irreversible ischemic injury can be minimized by pharmacological intervention or surgical approaches such as hypothermia, limited warm ischemia, or zero or segmental ischemia. Excessive loss of nephron mass can be minimized by improved preoperative or intraoperative imaging, use of a bloodless field, enucleation and vascular microdissection. Hemostatic agents or energy based resection that minimizes the need for parenchymal and capsular suturing can also optimize preservation of the vascularized nephron mass.

Abbreviations and Acronyms

CIT = cold ischemia time

CKD = chronic kidney disease

CT = computed tomography

GFR = glomerular filtration rate

PN = partial nephrectomy

RCC = renal cell carcinoma

VMD = vascular microdissection

WIT = warm ischemia time

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* Correspondence: Center for Urologic Oncology, Room Q10-120, 9500 Euclid Ave., Glickman Urological Kidney Institute, Cleveland Clinic, Cleveland, Ohio 44195 (telephone: 216-444-5595; FAX: 216-636-0770; e-mail: campbes3@ccf.org).

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Conclusions: Our understanding of the decline in renal function after partial nephrectomy has advanced considerably, including better appreciation of its magnitude and impact in various settings, possible etiologies and potential preventive measures. Many controversies persist and this remains an important area of investigation.

Key Words: nephrectomy, delayed graft function, ischemia

PARTIAL nephrectomy is the reference standard for the management of clinical T1a renal masses and its indications have recently been expanded to include T1b/T2 renal tumors, even in the presence of a normal contralateral kidney.[1] Compelling data on the implications of preexisting CKD have driven much of this change.[1–3] More than 25% of patients with localized renal cancer have preexisting CKD and can benefit from optimized function after PN to minimize the risk of progression to renal failure and increased mortality rates.[4] Young patients and those with familial RCC also require intensive efforts to preserve renal function after surgery.

While the main advantage of PN over radical nephrectomy relates to better function, even PN is associated with some functional decline because it requires the excision of functioning nephrons adjacent to the tumor and reconstruction, which can lead to focal devascularization. In addition, traditional PN has been performed in the setting of hilar occlusion and some nephrons may not recover completely from the ischemic insult.[5] During the last decade our understanding of the magnitude of functional decline after PN and potential etiologies has advanced substantially. We review these data and discuss preventive measures to minimize functional decline after PN.

METHODS

Our search strategy is highlighted in the abstract and supplementary Appendix (http://jurology.com/). The focus was 2006 forward correlating with routine use of estimated GFR for reporting. All articles were evaluated for quality and inclusion criteria independently by 2 authors (MCM, SCC) and a third was consulted when necessary (CE). Quality was assessed according to study design, level of evidence and quality of reporting. A synopsis of original data was generated with the priority of informing the practicing urologist of recent advances and their implications, including ongoing controversies.

MAGNITUDE OF FUNCTIONAL DECLINE AFTER PN

Several recent studies provide data on the magnitude of functional decline after PN in terms of global function or function specifically in the operated kidney.[6–16] Global functional outcomes can be further segregated based on patients with a contralateral kidney, where compensatory hypertrophy can be a factor, versus those with a solitary kidney. These data are summarized in the table, which provides the percentage of GFR saved in each of these circumstances relative to baseline function. These estimates pertain to function observed after early recovery has been achieved, typically after the first few weeks to several months after PN and, thus, represent the patient's new baseline level of function. The table is not intended as a meta-analysis but rather a summary of studies that provide meaningful data on this topic. There is naturally some variance in patient selection and surgical approach. Despite these considerations, the data in the table support certain approximations about the magnitude of decline of function after PN in this era.

For patients with bilateral kidneys, most series support the preservation of approximately 88% to 91% of global function after PN. This correlates with an approximate loss of 10% of global function related to the procedure. Most studies of compensatory hypertrophy after PN in adults have demonstrated only limited compensation in the contralateral kidney, representing 2.2% in a recent study[17] and 4% to 6% in most others.[6,13,18] In general, compensatory hypertrophy is blunted in adults compared to children and after PN compared to radical nephrectomy.[17] The signals sensed by the contralateral kidney are weaker after PN in strength (less change in nephron mass) and temporal characteristics (recovery after PN is rapid). Thus, most adult patients experience a minimal increase in contralateral function after PN. Given that the global functional decline after PN averages about 10% in the 2-kidney model, one can estimate that the percentage of functional decline in the operated kidney must average about 20%. This correlates with percentage of function saved in the operated kidney of approximately 80%, with some variance related to tumor size/location demonstrated in various series.

Mir et al assessed function specifically in the operated kidney after PN and their findings support these estimates.[6] They included patients with solitary kidneys and patients with 2 kidneys, with the latter group undergoing renal scans to provide split renal function. On average, 80% function was saved in the operated kidney. A multicenter series of 660